Description

The invention relates to an electroluminescent layer system as claimed in the preamble of claim 1.

Prior art

Electroluminescent layer systems are known. Inorganic or organic substances which can be excited by means of an electric voltage in order to emit light rays are used in said layer systems. In this case, the light-emitting substances are arranged, for example, between sheet electrodes, a first electrode being designed as a hole-injecting electrode (anode) and a second electrode being designed as an electron-injecting electrode (cathode). If the light-emitting substance is formed by an organic material, the excitation can be performed by means of a DC voltage source. In this case, the anode is connected to the positive pole of the DC voltage source and the cathode is connected to the negative pole of the DC voltage source.

Since it is known that the interfaces between the electrodes and the light-emitting organic material or the organic material itself degrade under the influence of oxygen and/or water, it is necessary, for long-term stability of the electroluminescent layer system, to provide suitable protection.

For this purpose, it is known, for example from EP 0 468 440 B1, to provide the cathode with a covering layer. The covering layer, which consists, for example, of pure metals, of co-deposited metal composites or of [illegible]

[illegible] between the cathode [illegible] by the covering

Furthermore, it is known from Appl. Phys. Lett. 65 (1994) pages 2922-2924, for the electroluminescent layer systems to be encapsulated by means of a glass pane which protects the electroluminescent layer system on both sides and is adhesively bonded at the edges. A drawback of this solution is that the encapsulation has to take place under an inert gas, so that the space between the rear side of the cathode and the glass pane is free of oxygen and hydrogen. A further drawback is that the glass pane is not flexible and therefore it is impossible to produce flexible electroluminescent layer systems.

Advantages of the invention

The electroluminescent device according to the invention having the features mentioned in claim 1, by contrast, affords the advantage that, firstly, there is efficient protection of the boundary layers which exist between the electrodes and the organic material and of the organic material itself against oxygen and water, and the electroluminescent layer system overall can be produced to be flexible. The fact that the encapsulation comprises a multilayer system, in which the layers of the multilayer system are preferably flexible and match the geometry of the electroluminescent layer system, advantageously makes it possible to create what is overall a sheet-like electroluminescent layer system which has a flexible structure and an extremely low permeation of oxygen and water.

[illegible]

[illegible] this way, encapsulation can be carried out highly

and a metal or metal oxide layer. The metal layer preferably consists of a metal which forms a stable passivating layer on the surface, so that long-term stability of the electroluminescent layer system is also ensured.

Furthermore, it is preferable if an additional getter layer is provided between the plastic layer and the metal layer. This has the highly advantageous result that any residues of oxygen and water which are present can be bonded by the getter layer, and consequently cannot contribute to degradation of the organic material.

In a further preferred configuration of the invention, it is provided for the getter layer to be embedded between two plastic layers, and for an outer plastic layer preferably to bear the metal layer. This has the highly advantageous result that the stability of the encapsulation can be increased while at the same time retaining its flexibility.

According to a further preferred embodiment of the invention, the electroluminescent layer system is arranged on a flexible support substrate, and the support substrate is preferably likewise provided with an encapsulation comprising a multilayer system. The multilayer system for encapsulation of the support substrate preferably has the same structure as the encapsulation of the electroluminescent layer system. Both the support layer and the encapsulation of the support layer are preferably of transparent or semi-transparent design, so that the light which is [illegible]

[illegible] and having an extremely low permeation [illegible]

In a further advantageous configuration of the invention, it is provided for the encapsulation, or at least parts of the encapsulation, to comprise a separate composite film or foil which has the individual layers of the encapsulation and is then applied to the electroluminescent layer system. In this way, the production of the electroluminescent layer system and the production of the encapsulation can be carried out separately, and it is then only necessary for the composite film or foil to be applied to the electroluminescent layer system. In this way, mechanical and/or thermal stresses on the electroluminescent layer system can be reduced during production.

Further advantageous configurations of the invention will emerge from the remaining features which are mentioned in the subclaims.

Drawing

The invention is explained in more detail below in exemplary embodiments with reference to the associated drawings, in which:

Fig. 1 shows a diagrammatic sectional illustration through an electroluminescent device, in a first design variant;

Fig. 2 shows a diagrammatic sectional illustration through an electroluminescent device in a second design variant, and

Fig. 1 shows an electroluminescent device, which is denoted overall by 10. The device 10 has an electroluminescent layer system 12 which is formed by a light-emitting organic material 14, a first electrode 16 and a second electrode 18. The electrodes 16 and 18 and the organic material 14 are of sheet-like design. The electrodes 16 and 18 are connected to a voltage source 20, for example a DC voltage source. The electrode 16 is in this case connected to the positive pole of the voltage source 20 and the electrode 18 is connected to the negative pole of the voltage source 20.

The electrode 16 consists of a material with a high electron work function. The electrode 16 may, for example, consist of a metal or a metal alloy or a metal oxide, for example indium tin oxide (ITO). The fact that the electrode 16 is connected to the positive pole of the voltage source 20 means that it is connected as an anode and, on account of the high electron work function, which is, for example, greater than 4.5 eV, it injects holes, which are transported into the organic material 14 as charge carriers.

The second electrode 18 consists of a material with a low electron work function which is, for example, lower than 4.5 eV. The electrode 18 consists of an electrically conductive material, for example of a metal, a metal alloy or a metal oxide. The electrode 18 may, for example, consist of aluminum, indium, magnesium, calcium, a magnesium-silver alloy or a magnesium-indium alloy. Connecting the electrode 18 to [illegible]

[illegible] light-emitting organic material 14. As a result, in the

electrodes 16 and 18, so that the organic substances in the material 14 are excited so as to generate light quanta. The electroluminescent layer system 12 can therefore be used as a light source.

The light-emitting organic material 14 which is used for this purpose contains at least one organic compound which, when the voltage is applied, is able to emit light. The color of the light emitted is in this case determined by the chemical structure of the organic substance used. The light-emitting organic materials 14 used are, for example, polymers, low-molecular-weight organic compounds, monomers or molecular-doped polymers. Further layers (not shown here), which are likewise used to emit light or to transport charge carriers to the light-emitting organic material 14, may be arranged between the electrodes 16 and 18.

The electroluminescent layer system 12 is applied to a support 22. Both the electrode 16 which is connected as an anode and the support 20 are in this case optically transparent or semi-transparent, so that the light which is generated by the light-emitting organic material 14 can be radiated outward by the entire device 10.

As can be seen from the illustration in Fig. 1, the electrodes 16 and 18 and the layers which produce the organic material 14 are arranged in a partially overlapping manner on the support 22, so that the connection regions 24 and 26 of the electrodes 18 and 16, respectively, bear against the support 22 and lead laterally out of an encapsulation 28, which is yet to [illegible]

The encapsulation 28 comprises a multilayer system 30,

layer 36 of a metal, a metal alloy or a metal oxide. The plastic layer 34 may, for example, consist of an acrylic resin, alkyd resin, epoxy resin, polyurethane resin, EVOH, polyester, PVC, PVDC, polypropylene, PMMA or other polymers and coatings. This plastic layer is applied to the electroluminescent layer system 12, for example by casting, centrifuging on, printing on or extruding on. Furthermore, the electroluminescent layer system 12 may be dipped into an appropriate bath, leading to dip-coating with the plastic layer 34. The way in which the plastic layer 34 is applied means that it matches the contour of the electroluminescent layer system 12 and therefore surrounds the latter on all sides, with the exception of the connection regions 26 and 24, and therefore encloses this system. The plastic layer 34 is then cured or crosslinked by thermal, chemical or radiation-induced means, so that a stable but flexible shell is formed.

A getter layer 38 is applied between the plastic layer 34 and the metal layer 36. The getter layer 38 consists of a material which has a bonding action for oxygen and water. The getter layer 38 consists, for example, of a metal which has an electron work function which is lower than or similar to that of the material of the electrode 18 which is connected as a cathode. For example, if the electrode 18 consists of magnesium, the material used for the getter layer 38 may be calcium, lithium or strontium. Alkali metals, alkaline-earth metals or rare earths may be used as material for the getter layer 38.

According to further exemplary embodiments, the getter [illegible]

[illegible] zeolites. With this selection of materials, the getter layer 38 may be deposited, for example, by

printing or doctoring. Furthermore, the getter layer 38 may, for example, consist of hygroscopic materials or compounds, for example zinc sulfide, copper sulfide, lithium chloride, applied by vapor deposition, these materials being applied as a thin film to the plastic layer 34.

The second layer 36 is applied to the getter layer 38. The layer 36 is selected in such a way that the getter layer 38 is completely surrounded, so that it has no contact with the outside. The second layer 36 consists, for example, of a metal, for example aluminum, copper, nickel, chromium, tin or tantallum, a metal alloy, for example nickel-chromium, or a metal oxide, for example aluminum oxide or silicon oxide, or a nitride layer, for example aluminum nitride or silicon nitride. The layer 36 may preferably be applied to the previously applied plastic layer 34 and the getter layer 38 by sputtering or vapor deposition. The layer 36, which forms the outer part of the encapsulation 28, leads to stable passivation of the entire device 10, so that it has a long-term stability with respect to outside influences. The metal layer 36 may additionally be passivated with a further layer, which is not shown in Fig. 1. By way of example, a polymer layer, a coating layer or an organically modified ceramic layer may be applied for this purpose.

Any residues or oxygen or water which arises as a result of leaks are, as it were, sucked up by the getter layer 38, so that they cannot reach the boundary layers between the electrodes 16 and 18 and the organic material 14 or come directly into contact with the [illegible]

[illegible] the multilayer system [illegible] layers, namely the plastic layer 34 and the metal

layer 38, comprises three layers, in each case of materials which are applied in a thin form, the overall flexibility of the device 10 is substantially unimpaired. Therefore, it is possible, despite the provision of the encapsulation 28, for the electroluminescent device to be adapted to the particular applications after production, i.e. after the layer systems have been constructed.

Further design variants of the electroluminescent device 10 are shown in Figs. 2 and 3, the encapsulation 38 having a modified structure in these variants. Identical parts to those shown in Fig. 1 are provided with identical reference numerals and are not explained again.

In the exemplary embodiment shown in Fig. 2, a further plastic layer 40 is arranged above the getter layer 38. The plastic layer 40 surrounds the getter layer 38 on all sides, with the exception of the contact surface between the getter layer 38 and the plastic layer 34. This plastic layer 40 has an insulating action and, at the same time, has sufficient flexibility. Instead of a plastic material, it is also possible to select another suitable material having these properties. The plastic layer 40 consists, for example, of the same material as the plastic layer 34 which has already been explained extensively in connection with Fig. 1.

When using certain metals, a further passivating layer 42 may be applied to the metal layer 36. This layer 42 may consist, for example, of a polymer, a coating or an organically modified ceramic.

[illegible] part-layers are designed in such a way that, overall,

the part-layers ensures that it is impossible for any residues of oxygen and/or water to reach the electroluminescent layer system 12, in particular the organic material 14. This prevents degradation of the organic material 14, so that overall the electroluminescent device 10 has a long-term stability.

In the case of the design variant of the electroluminescent device 10 which is shown in Fig. 3, a further encapsulation 28′ is additionally provided on sides of the support 22. The support 22 comprises, for example, a flexible substrate which has a certain permeability to water and oxygen. By way of example, it is possible to use a PET film which is approx. 100 µm thick. The encapsulation 28′ arranged on the support 22 has substantially the same structure as the encapsulation 28. The support 22 is adjoined by a getter layer 44, which is covered by a plastic layer 46. The plastic layer 46 is used to stabilize the getter layer 44. The materials which have already been mentioned for the getter layer 38 and the plastic layers 34 and 40 are also suitable as materials for the getter layer 44 and the plastic layer 46. A layer 48 which is impermeable to oxygen and water is applied to the getter layer 46. The layer 48 consists, for example, of a very thin application of aluminum, copper, nickel, chromium, tin, tantallum, gold or a metal alloy. Furthermore, it may consist of a thin film of oxide, for example of silicon oxide, aluminum oxide, titanium oxide, tantallum oxide or bismuth oxide, suitably modified to make it impermeable in water and oxygen. The selection of material and the application in a suitably known thickness of the layer 48, the [illegible]

[illegible] materials, at the same time, has the very

considerable advantage of making the electroluminescent device 10 anti-reflective via the encapsulation 28'.

A common feature of all three exemplary embodiments is that the encapsulation 28 or 28' in each case comprises a layer system 32. The individual layers of the layer system 32 are selected in such a way that they are flexible. To produce the electroluminescent device 10 which is provided with the encapsulation 28 or 28' according to the invention, it may be advantageous if the entire layer system 32 or alternatively only part-layers of the layer system 32, for example the plastic layers 34 and 40, with the getter layer 38 arranged between them, to be prefabricated separately as a composite film or foil. This prefabricated composite film or foil can easily be applied to the electroluminescent layer system 12, for example by adhesive bonding. For this purpose, the adhesive bonding may take place using heat-sealing adhesives, UV-curing adhesives or thermally or chemically curing adhesives.

Patent claims

1. An electroluminescent device having an electroluminescent layer system comprising a light-emitting organic material which is arranged between two electrodes which can be connected to a DC voltage source, a first electrode being a hole-injecting electrode (anode) and a second electrode being an electron-injecting electrode (cathode), and an encapsulation, wherein the encapsulation (28, 28') comprises a multilayer system (32).

2. The electroluminescent device as claimed in claim 1, wherein the multilayer system (32) has flexible layers (34, 36, 38, 40, 42, 44, 46, 48).

3. The electroluminescent device as claimed in one of the preceding claims, wherein the multilayer system (32) has a contour which matches the geometry of the electroluminescent layer system (12).

4. The electroluminescent device as claimed in one of the preceding claims, wherein the multilayer system (32) is applied to one side of the layer system (12) and surrounds the electrodes (16, 18) and the organic material (14).

5. The electroluminescent device as claimed in one of the preceding claims, characterized in that the multilayer system (32) comprises at least one layer (34, 40) which consists of plastic and a [illegible]

6. [illegible] consists of a metal, a metal alloy, a [illegible]

7. The electroluminescent device as claimed in one of the preceding claims, characterized in that an additional getter layer (38) is provided between the plastic layer (34) and the layer (36).

8. The electroluminescent device as claimed in claim 7, characterized in that the getter layer (38) is completely surrounded by the layer (36), except at the areas of contact with the layer (34).

9. The electroluminescent device as claimed in claim 5 to claim 7, wherein a further plastic layer (40) is provided between the metal layer (36) and the getter layer (38).

10. The electroluminescent device as claimed in one of the preceding claims, wherein the layers (34, 40) of plastic are centrifuged on, are printed on, are cast, are extruded on or are applied by dip-coating.

11. The electroluminescent device as claimed in one of the preceding claims, characterized in that the metallic layer (36) is applied by vapor deposition or sputtering.

12. The electroluminescent device as claimed in one of the preceding claims, wherein a passivating layer (42) is applied to the layer (36).

13. The electroluminescent device as claimed in one of the preceding claims, wherein the encapsulation [illegible]

14. [illegible] the preceding claims, wherein the multilayer

38, 40, 42, 44, 46, 48) of the multilayer system (32) comprise a separately prefabricated composite film or foil, which is applied to the electroluminescent layer system (12) in order to produce the encapsulation (28, 28').

Two pages of drawings

Electroluminescent layer system

The invention relates to an electroluminescent device having an electroluminescent layer system comprising a light-emitting organic material which is arranged between two electrodes which can be connected to a DC voltage source, a first electrode being a hole-injecting electrode (anode) and a second electrode being an electron-injecting electrode (cathode), and an encapsulation.

It is provided for the encapsulation (28, 28') to comprise a multilayer system (32).

Anmerkungen des Übersetzers

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Bei der Übersetzung des o.a. Textes schien uns folgendes unklar bzw. unrichtig zu sein. Wir haben uns deshalb erlaubt, Klarstellungen bzw. Berichtigungen vorzunehmen:

Seite/Abs./Zeile*	Anmerkung
4/40	"strahlungsind<u>u</u>ziert"
5/13-14	"Getterschicht 3<u>8</u>"